Model Human Processor (MHP)

- Developed by Card, Moran, & Newell
  - The Psychology of Human-Computer Interaction, 1983

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**MHP Basics**

- Based on empirical data
- Three interacting subsystems
  - perceptual, motor, cognitive
- Sometimes serial, sometimes parallel
  - serial in action & parallel in recognition
    - pressing key in response to light
    - driving, reading signs, & hearing at once
- Parameters
  - processors have cycle time (T) ~ 100-200 ms
  - memories have capacity, decay time, & type (physical, acoustic, visual, semantic)

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**Memory**

- **Working memory (short term)**
  - activated elements of LTM
  - small capacity (7 ± 2 "chunks")
    - 6174591765 vs. (617) 459-1765
    - DECIBMGMC vs. DEC IBM GMC
  - rapid access (~ 70ms) & decay (~200 ms)
    - pass to LTM after a few seconds

- **Long-term memory**
  - huge (if not “unlimited”)
  - slower access time (~100 ms) with little decay
MHP Principles of Operation

- Recognize-Act Cycle of the Cognitive Processor (analogous to fetch-execute cycle in computers)
  - on each cycle contents in WM initiate actions associatively linked to them in LTM ("recognize")
  - actions modify the contents of WM ("act")

- Discrimination Principle
  - retrieval is determined by candidates that exist in memory relative to retrieval cues
  - interference: other memory chunks may be more strongly activated by the associations used as retrieval cues

- Variable Cognitive Processor Rate Principle
  - CP cycle time $T_c$ is shorter when greater effort is induced by increased task demands/information
  - also decreases with practice

What’s missing from MHP?

- Haptic memory
  - for touch
- Moving from sensory memory to WM
  - attention filters stimuli & passes to WM
- Moving from WM to LTM
  - rehearsal
Perception

- Stimuli that occur within one PP cycle fuse into a single concept
  - frame rate necessary for movies to look real?
  - time for 1 frame < Tp (100 msec) -> 10 frame/sec.
  - for some Tp < 100 msec -> 20 frame/sec
- max. morse code rate can be similarly calculated

Volumetric Display
(fusing of 2D images to create 3D)
Perception

- Perceptual causality
  - two distinct stimuli can fuse if the first event appears to cause the other
  - events must occur in the same cycle

Perceptual Causality

- How soon must red ball move after cue ball collides with it?
  - must move in < Tp (100 msec)
Simple experiment

- Volunteer
- Start saying **colors** you see in list of words
  - when slide comes up
  - as fast as you can
- Say “done” when finished
- Everyone else time it…

- **Green**
- **White**
- **Yellow**
- **Red**
- **Black**
- **Blue**
Simple Experiment …

- Do it again…
Simple Experiment …

- Do it again…

Blue
Red
Black
White
Green
Yellow
Memory

- Interference
  - two strong cues in working memory
  - link to different chunks in long term memory

- Why learn about memory?
  - know what’s behind many HCI techniques
  - helps you understand what users will “get”
  - aging population of users

Stage Theory

- Working memory is small
  - temporary storage
    - decay
    - displacement
- Maintenance rehearsal
  - rote repetition
  - not enough to learn information well
- Answer to problem is organization
  - Faith Age Cold Idea Value Past Large
  - In a show of faith, the cold boy ran past the church
Elaboration

- Attach meaning (make a story)
  - e.g., sentences
- Visual imagery
- Organize (chunking)
- Link to existing knowledge, categories

Forgetting in Long Term Memory

- Causes for not remembering an item?
  - 1) never stored: encoding failure
  - 2) gone from storage: storage failure
  - 3) can't get out of storage: retrieval failure

- Interference model of forgetting
  - one item reduces ability to retrieve another
  - proactive interference (3)
    - earlier learning reduces ability to retrieve later info
    - e.g., drive to your old house instead of the new one
  - retroactive interference (3 & 2)
    - later learning reduces the ability to retrieve earlier info
    - e.g., change telephone numbers, can't remember the original
Recognition over Recall

- Recall
  - info reproduced from memory

- Recognition
  - presentation of info provides knowledge that info has been seen before
  - easier because of cues to retrieval

- E.g., Command line (recall) vs. GUI (recognition) interfaces

- (remember Nielson’s Heuristic #6)

Facilitating Retrieval: Cues

- Any stimulus that improves retrieval
  - example: giving hints
  - other examples in software?
    - icons, labels, menu names, etc.

- Anything related to
  - item or situation where it was learned

- Can facilitate memory in any system

- What are we taking advantage of?
  - recognition over recall!
Attention

- Filter in brain
  - Focus on certain things
  - Ignore the rest

- 3 types
  - Selective
    - Choose one thing to focus on
  - Divided
    - Try to focus on more than 1 thing at once
  - Captured
    - Stimuli that gets peoples attention

Selective Attention

- Pick one thing to focus on, amongst many possibilities
- Eye movement to item of interest
- Head movement to sounds of interest

- Cocktail party effect
  - Ability to “tune out” numerous conversations in same vicinity and focus on just one

- Single “locus of attention”
Divided Attention

- Do multiple tasks
  - Either “simultaneous”
  - or time multiplexed (rapidly alternate)

- Can degrade performance
  - If combined tasks exceed human abilities

- Interference between tasks

Chunking & UI Design

- Remember: 7±2
- Create cognitive chunks:
  - Progress from general to specific

Menubar example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml
Chunking & UI Design

- Chunking menus:

  ![Menu Bar Example](http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml)

Visual separation
- Use whitespace to separate info into groups

Visual differentiation
- Change visual characteristics of different groups to cause chunking

Visual progression
- Rely on visual and cognitive cues to guide order in which users internalize information

![Button Example](http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml)
**Chunking & UI Design**

- **Visual separation**
  - Use whitespace to separate info into groups
- **Visual differentiation**
  - Change visual characteristics of different groups to cause chunking
- **Visual progression**
  - Rely on visual and cognitive cues to guide order in which users internalize information

Dialog box example from: http://www.interfacemafia.org/articles/200109/200109-ar0002.shtml

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**Gestures**

- **Sequence of actions completed automatically once set in motion**
  - E.g., typing the word “the”
    - Single gesture for experienced typist
    - Three gestures for novice typist
  - E.g., keying in phone numbers, passwords
- **Haptic analogue to cognitive chunking**
- **UI guideline: facilitate gestures/phrases that result in haptic chunking**
Modes

- Relates to how interfaces responds to a given gesture
  - In a mode if interpretation of a gesture is constant
  - In a different mode if gesture interpreted differently
  - E.g., tapping “Enter” key
    - Inserts return character into text in one mode
    - Executes a command in another mode

- Can be troublesome
  - E.g., CapsLock key
    - !@$#@#%
  - Causes “mode errors”

Minimizing mode errors

- Do not have modes!

- Ensure modes distinctively marked

- Ensure commands required in different modes are different
  - i.e., gesture issued in a wrong mode will not result in difficulty
**Quasimodes**

- Kinesthetically maintained modes
  - e.g., holding shift key rather than CapsLock
  - do not cause mode errors

![The hunchback of Notre Dame](from Raskin, The Humane Interface, pg 55)

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**Noun-Verb vs. Verb-Noun dialogues**

- E.g., change font of a paragraph of text
- 2 ways to do it:
  - Choose *verb* (change font) first
    Then select *noun* (paragraph) to which verb applies
  - or
  - Choose *noun* first, then apply *verb*

- What’s the difference?
Noun-Verb interaction preferred (sometimes called Selection-Action)

- Error reduction
  - Verb-noun is modal.
    - Once command (verb) is selected, it effects next selection (noun). If there’s a delay between actions, and wrong selection made, results can be surprising
  - Noun-verb is non-modal
    - Command (verb) executed immediately when issued

- Speed
  - Attention remains on item of interest
    - First on content/selection (noun), then on action (verb)
      - (in verb-noun, attention moves from content to action and back to content again. Noun-verb uses one less attention switch)

- Simple & Reversible
  - No escape/cancel operation needed
    - (in verb-noun, if you issue a command and want to cancel it, have to explicitly issue cancel operation. In noun-verb, just select something else).

- Is noun-verb always possible?
Readings
